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Virtual Design Reviews and Tours – Connecting With the User and Capturing Timely Feedback

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ABSTRACT

Virtual reality is more than a novelty at your local gaming center; it is a critical component for the military's development of weapon systems. For the past three years, the U.S. Army has been using state-of-the-art virtual technology to accelerate the acquisition process. The National Automotive Center's (NAC) Advanced Collaborative Environment (ACE) Group has been working with the Stryker Brigade Combat Team (SBCT) and Future Combat Systems (FCS) program to conduct systems integration events, where the end-user is involved from the very beginning. Virtual design reviews enable engineers to display their system designs to the warfighting community. The results of such reviews include critical and relevant feedback from the ultimate consumer of the system.

INTRODUCTION

The Army's programs for transformation have very aggressive schedules fielding vehicles that cannot be met using the traditional method of program development. The traditional methods of product and system design, development, and acquisition have often been described as serial and linear processes where functional groups make contributions sometimes independent of other internal and external elements. Working with this process often requires many expensive physical mockups that do not reach the warfighter until late in the acquisition process. Since the warfighter does not have much input during the design process, the system often fails to reflect their actual needs. Virtual design reviews help to overcome the limitation of this approach by connecting the distributed functional groups, such as engineer and warfighter, so that they might make better, more informed and timelier decisions to substantially reduce overall system design cost, risk and development time while improving life cycle quality and utility. Our immersive technology allows the user to take a direct, active role in creating a quality vehicle, and increasing operational effectiveness.

By leveraging commercial technology, software support and maintenance is handled by the commercial company thereby reducing costs of software design, maintenance and support of in-house software. Using immersive software allows for system designs to be examined and changes to be made before any physical prototypes are built. Soldiers, trainers, and engineers can come together in the early stages of the design process to build a vehicle that works better, costs less, and requires fewer changes once it is in the field. Figure 1 shows a design review taking place that involves an engineer from a vendor, his leadership,

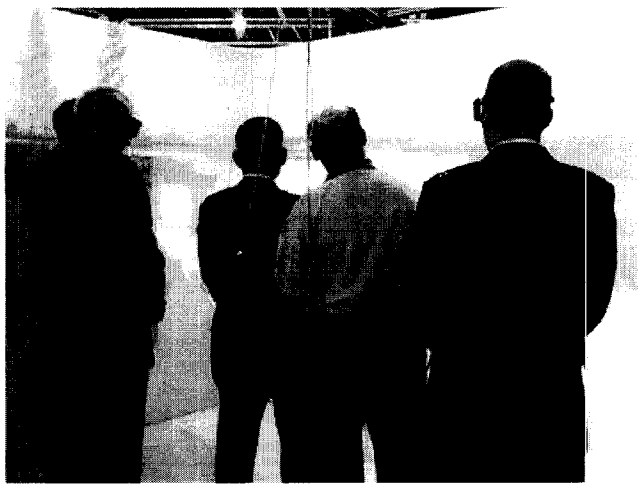

Figure 1

and Army leadership. The use of design reviews to communicate complicated engineering issues to leadership is another important task that can be accomplished in a collaborative environment. In addition to this discussion, this paper will also describe how other communities that have a stake in the design of the vehicle, such as testers, maintainers, logisticians, etc. are able to harness the power of these virtual design reviews to accelerate the way they do business.

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CONDUCTING VIRTUAL DESIGN REVIEWS

A virtual design review, defined for this paper, is a review held in a virtual environment involving multiple stakeholders in an Army program. The virtual environment used at the NAC is a CAVE™ (Cave Automated Virtual Environment), shown in Figure 2. The

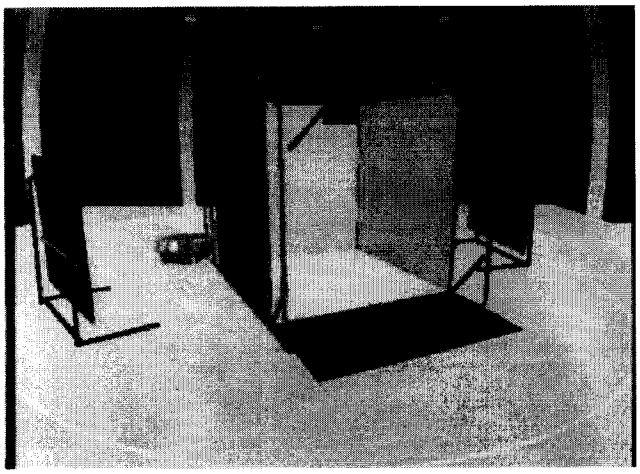

Figure 2

CAVE™ is a virtual reality system that is rear-projected with stereoscopic images, creating the illusion that 3D objects appear to coexist with the user in the room. To view the images, the user wears a pair of lightweight liquid crystal shutter glasses and uses a wand for interaction with the virtual environment. The glasses and wand are tracked so that the computer can determine the user's location and orientation of the user's head and hand at any given time. This syncs the imagery that the computer produces to what the user thinks they should be seeing. This way a user can physically walk around an object, look behind it, and look underneath it. Speakers are mounted to give the surround sound feel of an environment and to provide audio from linked, distributed participants.[1]

DESIGN REVIEW PROCESS

Design reviews can be held for many different reasons. However, the main focus should always be to determine whether or not the requirements are being fulfilled. Other reasons (which should be secondary) may include education (of both other team members and the customer), a springboard for new ideas (brainstorming) or to review the performance of a subcontractor. There are many pieces that must be in place before conducting a virtual design review. Prior to the review the proper hardware and software need to be in place, relevant stakeholders need to be determined, and the data being reviewed needs to be processed. Once these requirements are met, the review facilitator sets up a meeting time, invites attendees and conducts the review.

Hardware and Software Requirements

The main piece of hardware required is a device capable of immersing the user in a virtual environment. The Army is using the CAVE™ immersive device. This device allows six (optimal number) or more users to be immersed in the virtual environment at the same time. The NAC has four CAVE™ systems, one located at the NAC in Warren, MI, one located at the Unit of Action Mounted Battle Lab (UAMBL) in Ft. Knox, KY, one located at Altair Engineering in Troy, MI as part of a Cooperative Research and Development Agreement (CRADA), and one that is portable and can be set up anywhere known as a RAVE™. The following list shows the hardware specifications of the CAVE™ located at the NAC:

- 1 5-Wall CAVE Structure and Screens
- 5 Christie Digital Mirage 4000 DLP Projectors
- 1 InterSense Wireless Tracking System (IS-900)
- 3 FakeSpace System IR Blaster and Cabling
- 5 Stereographics Crystal Eyes III LCD Eyewear
- 5 Extron Interface Units
- 1 Control Electronics Equipment Rack
- 4 Tannoy full-range, time-aligned speakers
- 1 Electrovoice sub-bass unit (350 watts)
- 2 Mackie dual channel amplifiers (200 watts/channel)
- 1 Mackie audio mixer
- 1 Alyesis AI3 ADAT digital to analog
- 1 SGI Onyx 2000 (or better)

In order to use the CAVE™ system it requires a software package that produces a stereo image and can be configured to produce a correct image for each wall. The software package used by the NAC is Parametric Technology Corporation's© Division Mockup™ 6.02. The data starts in native CAD format such as ProEngineer™ or Unigraphics™ and is converted to Mockup™ to produce the 3D images. In addition to the main software package some support packages used are:

- Multigen-Paradigm© Creator™
- Autodesk© Lightscape™

- Alias|Wavefront© Maya™
- Discreet© 3D Studio Max™

Key Players

The number of people involved in a design review can range from 3 people to over 100 people; it all depends on the event and focus of the design review. There is always at least one expert from the ACE group to facilitate the technology portion, answer immersive technology related questions, and guide the users through the virtual environment. In addition to the ACE expert, a facilitator to conduct the review, i.e. program manager for a vehicle, needs to be present. It is the facilitator that is conducting the review that determines the relevant stakeholders that need to be involved. For example, the review may involve engineers from the vendor designing the vehicle, representatives from the warfighter community, representatives from the PM, and representatives from a vendor subcontractor. The focus of this review may be the design of a particular subsystem that needs the warfighters concurrence.

The focus of each review should be making sure that the requirements are being met, but different requirements need the participation of different functional groups. Involving many participants from various areas gives a greater probability for making more informed decisions quickly. Each person involved in the review has a different educational background, therefore each one of them receives and processes information differently. It is improbable that two participants that come from different functional groups and are involved in the same design review will come to the same conclusion. Since each person is looking at the same information from a different point of view, communication between parties can be enhanced during a virtual design review, allowing all parties to brainstorm or solve a problem with the results being satisfactory to all parties involved, allowing for early consensus, which in the past has been difficult to achieve.

Stages of a Design Review

The first stage in a design review is data preparation. Once the data is received in native CAD form, it is tested to make sure that the data is in the correct form and no errors exist that would prevent it from being converted. If an error is encountered, the vendor is contacted to provide the fixed data. Errors can occur for many reasons; the data can be missing, corrupt, or just copied incorrectly. If the CAD model is relatively small then the entire vehicle can be converted all at once. For the models that contain manufacturing CAD data the conversion process takes place at the smaller subsystem level.

Once the data is converted, the ACE technicians work with the facilitator to create a template or storyboard for the review to follow. The storyboard is a walk-through of the model being reviewed in the virtual environment and can include fly-throughs, animations to show functionality and operational ability. Having a storyboard allows the facilitator to insure that certain views are seen by the audience so that the virtual design review gets all fo the points across that the facilitator needs everyone involved to understand, however it also leaves them free to explore alternate views in the virtual environment as needed. Figure 3 shows a sample storyboard for the

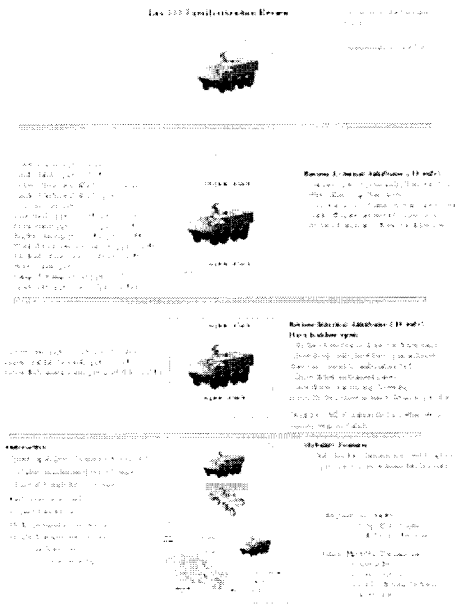

Figure 3

SBCT Interim Carrier Vehicle (ICV) variant. Each storyboard is developed to provide a good experience for the user and to facilitate communication about the outstanding issues. These designated stops allow the facilitator to control the direction of the review but leave room for unexpected stops. "If we create a linear storyline for the viewer to follow we are creating a 3D movie. However, if we allow the viewer complete control there is no guaranteeing that the intended point will be made."[2] Once the storyboard is developed, one final meeting with the facilitator takes place to ensure that all the information is covered and that no changes need to be made before the review.

At the beginning of the review the attendees get a short brief to introduce the technology and what they will be experiencing. In addition, there may be participants at distributed locations so everyone is introduced through a video conferencing system. Once everyone is ready, the facilitator begins the review by introducing the vehicle and discussing the relevant topics for the meeting. As participants become more comfortable with the technology, they begin to interact with the vehicle and brainstorm possible solutions to issues. Throughout the review feedback and questions are recorded to be uploaded into the information database for further review or comments.

Another function of using virtual design reviews is graphically showing results of testing, such as vehicle

dynamics, to support the design. Traditionally these results are shown in the form of a spreadsheet with hundreds of numbers and are only meaningful to the technicians in that particular field. Using virtual tools allows for any person from any background to see and understand the results of tests from many fields. This is a great advantage when trying to make an engineering point to management as they can see what is happening and understand why the results are important to the design.

END RESULT – SAVING TIME AND MONEY

The interactive quality of a virtual design review makes it easy for everyone to understand what is being reviewed because it does not require any technical expertise. While engineers and vehicle system integrators are experienced at reading and reviewing CAD drawings and models, the average logistician is not. Using the virtual environment as a medium, the visual data provides a common language for discussions across diverse backgrounds and work competencies. By involving the end user at the front end of the acquisition process, soldiers and engineers can come to conclusions which result in early acceptance of a design which may have caused controversy if it had not been discussed until after physical prototypes had been built.

In addition to accelerating soldier acceptance, communities that have to wait for the physical prototype in the traditional design process have access to virtual data and can begin using that data to accelerate their processes. For example, the communities responsible for installing training equipment on the vehicle have access to the design early on which allows them to make decisions regarding space and placement of their hardware before ever needing the physical vehicle. The functionality of equipment can also be demonstrated in a virtual world to show that it meets requirements. Access to the virtual design also allows individuals in the maintenance and training communities can begin to develop plans for manuals.

As a result of better decisions being made early in the acquisition process, less expensive physical prototypes need to be built. Also, once the prototype is built less hardware needs to be redesigned because most problems can be caught early on. This means that once the vehicle is in production, the Army spends less money on changes.

SUCCESS STORY – SBCT

The SBCT was designed to be the Army's interim vehicle. It began as a Canadian LAV III and was modified to meet the needs of the US soldier. Over the span of four years, the vehicle was designed and began production and fielding. This could not have happened without using modeling and simulation to support the design process. The time to market was greatly reduced by using the CAVE™. By using the virtual models instead of physical mockups, a greater number of designs were evaluated. The SBCT program consists of 11 variants that had to be introduced and approved by the various Army communities. The variants are:

- Infantry Carrier Vehicle (ICV)
- Command Vehicle (CV)
- Reconnaissance Vehicle (RV)
- Nuclear Biological Chemical Reconnaissance Vehicle (NBC RV)
- Mortar Carrier Vehicle A (MCV A)
- Mortar Carrier Vehicle B (MCV B)
- Anti Tank Guided Missile (ATGM)
- Medical Evacuation Vehicle (MEV)
- Mobile Gun System (MGS)
- Engineering Support Vehicle (ESV)
- Fire Support Vehicle (FSV)

Over 1500 people overall were involved in the virtual design reviews. The reviews took place at the ACE facility, the UAMBL facility, and at Army trade shows. The stakeholders came from both army and industry personnel. In addition to getting the user involved, these reviews allowed leadership to get involved. Doing reviews at the trade shows generated interest in the program and created a desire by everyone to ensure that the program was a success.

The first major design review for the SBCT program was for the ICV. The program was only a year old and involved brand new systems that had never been used by the US Army. One new system was the Remote Weapon System (RWS). It was a system developed in Norway that gave soldiers the ability to fire a weapon while remaining under armor at all times. The previous weapon systems required the vehicle commander to be out of hatch to fire the weapon. The new system was designed to keep the soldier safely inside the vehicle at all times. However, there were drawbacks that the soldiers had to accept. If the electrical system malfunctioned, there would be no way for the soldier to manually fire the weapon because of its height above the hatch. Also, the weapon sits directly in front of the commander's hatch, effectively blocking his view of what is in front of the vehicle. By using the immersive tools, engineers showed the soldier what the drawbacks were for this weapon and got their acceptance that the drawbacks were worth the what would be gained by using this weapon.

Another example involving the RWS and the soldier is the way that the weapon is stowed for transportation in a

C130 transport plane. The RWS sits on a platform that is bolted down with six bolts. In order to stow the RWS, the six bolts must be removed and stowed somewhere. During the slide presentation the soldiers did not see this and it went without discussion until the soldier participated in the virtual design review. During the review the RWS was shown going through the stowing process and the soldier was able to watch this animation from any angle or position. While watching the animation from the commanders hatch the soldier wanted to know what was expected to happen to the six bolts that secure the RWS to its platform while the vehicle was being transported. The engineer responded that the soldier responsible for stowing the RWS would put the bolts in his pocket. Obviously this was unacceptable to the soldier who knew these bolts would inevitably get lost, so the engineer modified the design to accommodate self-stowing bolts. The SBCT stakeholders were able to iron out integration issues six months before the hardware was in the country, saving the program time and money.

These are just two of the many integration issues that were found and solved using virtual design reviews. This new technology has revolutionized the Army's acquisition process. It is the key to meeting the aggressive schedules of the future. The success of the SBCT program shows that without these tools, stakeholders would not have been able to see and experience the designs and make decisions simultaneously.

USING ACE IN FCS

The Future Combat System (FCS) program has stated that due to accelerated timelines many decisions need to be made concurrently and more efficiently.[3] The Simulation Support Plan (SSP) states that Modeling and Simulation (M&S) is the only way that the program can remain on schedule and budget. Virtual design reviews are a key piece of M&S. FCS is not just one new vehicle, it is a system of systems involving new manned ground vehicles as well as unmanned ground vehicles and unmanned aerial vehicles. New communication systems will be employed as well as new weapon systems. If FCS is going to be ready in FY10, decisions will need to be made as quick as possible and once the system is in production, changes need to be minimal.

Virtual design reviews are already being used to develop the designs for the manned ground vehicle platforms. During the vendor selection process, designs were submitted and reviewed in the CAVE™. Now, new model updates are being received regularly and the relevant players are discussing trade-offs and solutions.

Figure 4

Figure 4 shows a picture of a fleet of concept vehicles, but the designs are purely conceptual at the time of this writing. Using the ACE tools, designers can make those concepts a reality, faster and cheaper than past processes.

Another new technique in vehicle design is the Pit Stop Engineering process. Vehicle components are designed so that if they are a standard size and can be replaced quickly if it breaks. Most of the work is being done with small scale replicas of the parts but by using the ACE tools, the results of the process can be easily captured and shown to groups and individuals who were unable to participate in the process.

CONCLUSION

The acquisition timelines of the future are getting more aggressive. By employing more virtual design reviews and less physical prototypes the Army can evaluate more design options at a lower cost and produce a system that meets warfighter needs and has better operational performance. The SBCT program saved nearly a year's time and unknown millions of dollars. Due to its success FCS has adopted some of the same processes. While a system to conduct virtual design reviews does require an initial investment the cost savings of doing business in a virtual world are immeasurable and the time savings are the key to meeting significant milestones.

In the future, virtual design reviews can be developed to accelerate other Army processes. One community that will one day be able to employ virtual reviews to their processes is the testing community. Right now they need physical hardware to perform vehicle tests such as what will be affected if a vehicle is penetrated by a particular round. Virtual reviews can connect the testers to the current design data and allow them to view exactly what would be affected by a given round's behavior. Also, the simulation community is already using virtual tools to do business but it is not connected to all the stakeholders and is not concurrent with the design process.

Automobile manufactures are using virtual reviews but mostly for the style and aesthetic design of a vehicle. As the processes evolve the Army hopes to continue partnerships with the automakers to help them realize the potential for using virtual design reviews to do systems integration also.

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